

# **Framework for Managing Wastes from Oil and Gas Exploration and Production (E&P) Sites**

---

**Environmental Science Division**

**About Argonne National Laboratory**

Argonne is a U.S. Department of Energy laboratory managed by UChicago Argonne, LLC under contract DE-AC02-06CH11357. The Laboratory's main facility is outside Chicago, at 9700 South Cass Avenue, Argonne, Illinois 60439. For information about Argonne, see [www.anl.gov](http://www.anl.gov).

**Availability of This Report**

This report is available, at no cost, at <http://www.osti.gov/bridge>. It is also available on paper to the U.S. Department of Energy and its contractors, for a processing fee, from:

U.S. Department of Energy

Office of Scientific and Technical Information

P.O. Box 62

Oak Ridge, TN 37831-0062

phone (865) 576-8401

fax (865) 576-5728

[reports@adonis.osti.gov](mailto:reports@adonis.osti.gov)

**Disclaimer**

This material was prepared as an account of work sponsored by the participants in Petroleum Environmental Research Forum (PERF) Project 2003-03. Neither the United States Government nor any agency thereof, nor UChicago Argonne, LLC, nor any of their employees or officers, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of document authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

# **Framework for Managing Wastes from Oil and Gas Exploration and Production (E&P) Sites**

---

for  
The Participants of the Petroleum Environmental  
Research Forum (PERF) Project 2003-03,  
"Managing Waste in Countries with Little Infrastructure"

by  
J.A. Veil and M.G. Puder  
Environmental Science Division, Argonne National Laboratory

August 2007



## Introduction

Oil and gas companies operate in many countries around the world. Their exploration and production (E&P) operations generate many kinds of waste that must be carefully and appropriately managed. Some of these wastes are inherently part of the E&P process; examples are drilling wastes and produced water. Other wastes are generic industrial wastes that are not unique to E&P activities, such as painting wastes and scrap metal. Still other wastes are associated with the presence of workers at the site; these include trash, food waste, and laundry wash water.

In some host countries, mature environmental regulatory programs are in place that provide for various waste management options on the basis of the characteristics of the wastes and the environmental settings of the sites. In other countries, the waste management requirements and authorized options are stringent, even though the infrastructure to meet the requirements may not be available yet. In some cases, regulations and/or waste management infrastructure do not exist at all. Companies operating in these countries can be confronted with limited and expensive waste management options.

## Purpose

This report represents the second phase of a project designed to develop a framework for waste management guidelines for consideration by oil and gas companies operating in areas that may not be covered by detailed requirements. The guidelines may also be used as the basis for advocating future regulations in countries that do not currently have comprehensive waste management requirements in place.

In the first phase of the project, Argonne National Laboratory compiled and compared the waste management requirements from six different jurisdictions: the United States of America, the State of Louisiana, the Republic of South Africa,

Canada, the Province of Alberta, and the World Bank Group. The U.S. Department of Energy (DOE) and several companies who joined PERF Project 2003-03, “Managing Waste in Countries with Little Infrastructure,” jointly funded the first phase of the project. PERF Project 2003-03 resulted from discussions held within the Petroleum Environmental Research Forum (PERF).<sup>1</sup> The companies participating in PERF Project 2003-03 funded the second phase of the project.

### Scope

This framework is intended to provide general guidelines for managing wastes rather than listing detailed, specific standards for individual waste management practices or waste streams. The framework presents several overarching, general principles regarding wastes and sound waste management. These principles could be augmented by site-specific criteria in the context of a particular E&P waste management operation, and they could be incorporated into new or updated regulatory programs. The framework is thus a living document that can be revised and customized for use in different jurisdictions.

### General Principles for E&P Waste Management

#### **1. Wastes Are an Inevitable By-Product of E&P Operations — Plan Early**

The drilling and completion of wells and the production and handling of oil, gas, and water generate materials, many of which can be considered wastes. E&P activities require heavy machinery, the use of chemicals and industrial commodities, and infrastructure for support personnel. Often operations take place in remote locations that require companies to provide basic life-support services for the

---

<sup>1</sup> PERF is a nonprofit organization created in 1986 to provide a stimulus to and forum for the collection, exchange, and analysis of research information relating to the development of technology for health, environment and safety, waste reduction, and system security in the petroleum industry. PERF generally operates through joint projects that are voluntarily joined by PERF members on a project-by-project basis. For this project, Argonne was contracted by ChevronTexaco (now Chevron), which acted on behalf of several other companies, including ExxonMobil, Unocal, Total, Statoil, and Halliburton.

workers, including the provision of food, water, shelter, and medical support. Waste generation is a natural consequence of E&P operations. The key to reducing waste volumes and mitigating waste impacts is a proactive life-cycle approach to waste management. A life-cycle approach evaluates waste minimization and management improvements in all stages of an operation — from project planning, construction, and operations through waste treatment and disposal — rather than just looking at “end of pipe” waste disposal options.

All stages of the waste management life cycle are important in terms of their potential for impacting human health and the environment as well as influencing the waste management costs incurred by E&P operators. Inadequate management of wastes can also have long-term implications in terms of future legal liability and negative impacts on a company’s reputation. Operators are well-advised to plan for sound waste management practices early in the process of siting and producing a field. This planning not only protects the environment but also benefits the company’s reputation and helps the company build strong relationships with local communities.

In this light, companies should know the types of wastes that are generated at a site, the characteristics of each type of waste, and the anticipated volumes of each type of waste. Companies should develop, implement, and update comprehensive waste management plans on the basis of this information. Tracking systems should be deployed to monitor how different wastes are managed to ensure that the plans are being followed and that any applicable regulatory requirements are being met.

## **2. Not All Wastes Pose the Same Potential Risk — Management Requirements Are Different**

E&P operations generate numerous types of materials. Some of these have chemical, physical, or biological characteristics that may impact the soil, water, and air and human and ecosystem health if not managed properly. The selection of an appropriate waste management option should reflect the various characteristics of

the materials. In general, a wider range of waste management options can safely manage wastes with lower potential risks, while wastes with higher potential risks typically may have more limited management options. Examples of higher-potential-risk waste materials include used acids, solvents, and biocides. On the other end of the spectrum, water-based drilling muds and cuttings and food waste are examples of lower-potential-risk waste materials.

Many countries and jurisdictions that have existing regulatory programs for E&P wastes distinguish between categories of wastes that pose higher potential risks and those that pose lower potential risks. The terminology may differ (for example, hazardous/nonhazardous or dangerous/nondangerous), but the basic concept is similar. Some jurisdictions provide special legal classifications for wastes that are directly part of, or associated with, E&P activities; for example, there is an E&P waste exemption in the United States. Typically, these wastes are considered to have less potential to impact human health and the environment and are subject to fewer restrictions. Often generic industrial waste or other general waste is to be managed under regulations that are applicable to all industries, communities, or businesses.

Wastes with similar characteristics and potential risks should be managed in a similar way. In contrast, wastes with different features, and especially those posing substantially different levels of potential risk, should not be combined before treatment or disposal, because the characteristics of one part of the mixture may cause more stringent standards and/or treatment requirements to apply to the entire mixed waste volume. A comprehensive waste management plan should include guidance explaining how and where to store and manage wastes of different types. Tracking systems, such as manifests, provide greater assurance that wastes are being managed in the intended way and in compliance with any applicable regulatory requirements.

### **3. Not All Locations and Settings Have the Same Potential for Waste-Related Impacts — Acceptable Management Techniques Vary by Location**

Fundamental differences may exist from country to country and between regions within a country in terms of climate, hydrology, geology, proximity to human and animal populations, and modes of waste management operations. For example, the potential impact from land-spreading tank-bottom sludge on the ground is quite different in a dry, desert environment than in a moist, tropical, coastal environment or in an Arctic tundra environment. In some cases, produced water may not be discharged to onshore streams or rivers but may be routinely discharged to the ocean. Economics, politics, administrative procedures or laws, and social practices also affect the types of waste management practices that are followed.

In this light, environmental regulatory programs should be crafted in a manner that reflects these differences. This means that wholesale transfers of regulatory blueprints from other jurisdictions and “one-size-fits-all” approaches may not be environmentally appropriate and are not advisable. For example, regulations governing waste management operations in Alberta may not fit operations in Africa because of differences in the environment and climate, availability of infrastructure, and other factors. Rather, programs can and should vary from country to country and even within portions of a country or region.

Countries that are looking to establish new waste management regulatory standards, whether for E&P operations or more generally, should not automatically adopt the standards of other countries without understanding the structure and function of the entire regulatory system in the other country. An assessment of waste characteristics and potential risks balanced against an assessment of the available infrastructure and the country's general waste management goals should be the basis for regulations. A strategy that selects and combines the strictest elements from regulatory programs adopted in several other countries into a new regulatory program can easily lead to unrealistic and expensive waste management requirements that do not offer environmental benefits commensurate with costs.

#### **4. A Waste Management Hierarchy Should Be Followed When Technically Feasible and Affordable**

Over the past few decades, oil and gas operators have looked increasingly to the life-cycle waste management approach that minimizes the generation of wastes and uses disposal techniques that offer greater environmental protection and public safety. The basic concept of a waste management hierarchy follows several tiers of options. The number and designations of tiers offered in the literature vary depending on the subcategory, such as waste minimization, recycling/reuse, treatment, or disposal. Under waste management hierarchy models, a company should manage wastes in a manner that provides environmental protection while meeting the needs of the business and country or community. The following example of a waste management hierarchy uses three tiers.

The first tier is source reduction or waste minimization. In this tier, process modifications, technology adaptations, or product substitutions are implemented to reduce or eliminate the amount of waste generated or the potential impacts posed by the waste. When feasible, waste minimization can often save costs for operators and result in smaller volumes of waste for management in the local communities and environment.

For wastes remaining after the waste minimization stage, operators next move to the second tier: recycling and reuse of materials that would otherwise be managed as wastes. For example, many offshore drilling rigs have begun using cuttings driers to remove and recycle nonaqueous drilling fluids before discharging cuttings to the ocean. Recycling expensive fluids reduces costs by reclaiming the fluid and minimizes the amount of fluids that are discharged. Another example is the use of produced water injection to enhance oil recovered from the reservoir, and a third example is the recovery of hydrocarbons in crude oil tank bottoms and other oily sludges. Other materials like oil filters, antifreeze, wooden pallets, spent solvents, unused chemicals, glass, shipping skids, and scrap metal are routinely recycled, if the infrastructure exists.

Some materials, by-products, or wastes generated at E&P sites could be provided to local communities for reuse where reuse might be appropriate (i.e., the materials do not pose potential negative impacts to human health or the environment). Examples include pallets and construction materials. Other wastes may be able to be reused within the E&P facility's own operation. For example, a company drilling in an arid area may use produced water as a source of makeup water for mixing drilling or workover fluids; it thereby uses less of the scarce local fresh water. Or partially spent caustic sweetening solution may be found suitable for use as reagent in sulfur dioxide scrubber units at a natural gas processing plant.

Wastes that cannot be recycled move into the third tier: treatment and disposal. Some wastes may first require stabilization or some other treatment to reduce their potential impacts. Many different technologies are employed throughout the industry for treating and disposing of E&P wastes. Some common examples of treatment technologies include separation/settling, filtration, solidification, stabilization, bioremediation, thermal treatment, centrifugation, and flotation. Some basic disposal techniques include burial in pits, landfilling, land spreading, discharge, and underground injection.

The ultimate disposition of the waste is a significant factor influencing the level of treatment. For example, produced water destined for injection underground is often filtered to remove solids and oil that could plug the formation receiving the water. Biocides and corrosion inhibitors may be added. On the other hand, produced water destined for ocean discharge may be treated to reduce oil and grease and control toxicity as necessary. If the discharge involves fresh water bodies, the salinity of the produced water must also be properly addressed.

## **5. Infrastructure Availability Places Boundaries on the Available Waste Management Options**

In areas where oil and gas have been produced in large quantities for several decades — for example, the U.S. Gulf of Mexico or the North Sea — oil companies,

service companies, or third-party disposal companies have often established an infrastructure to manage waste that must be disposed of onshore. In addition, other components of the transportation, recycling, and treatment/disposal infrastructure (roads, dock facilities, treatment units, and landfills) are readily available. Where this type of infrastructure exists, wastes can be collected from E&P sites and managed at commercial recycling or disposal companies or government landfills.

In more remote regions or areas without a long history of E&P activity, a comprehensive infrastructure network generally is not available. E&P operators in these areas have fewer options and may need to create their own infrastructure and/or waste management facilities. The initial costs of building and properly operating facilities in these locations are generally higher, but those costs are offset by the reduced long-term life-cycle management costs.

In addition to these more obvious infrastructure issues, other supporting functions may not always exist. For example, many countries or remote areas will not have fully equipped analytical laboratories. Companies will have to bring that capability to the site or plan to transport samples to another location that does have the analytical capability. In such scenarios, it may not be practical to undertake waste management options or impose operational or regulatory standards that will require frequent and complex analytical work.

## **6. Waste Management Program Requirements Should Be Clearly Stated**

Oil and gas E&P operators should develop and implement waste management plans tailored to a region or site. These plans should, at a minimum, comply with the waste management requirements of the host country, or they should assure use of sound management practices when regulations are lacking. Waste management plans should be written in the host country's official language as well as the operating company's language by using clear, easily understandable terms. The

plans should be made available to governments, lending institutions, and other interested parties, as appropriate.

Countries hosting oil and gas E&P operations should develop regulatory programs or guidelines assuring that any wastes are managed in an environmentally responsible manner. The programs should be developed through a process that allows for review and comment by the public, including industry, nongovernmental organizations (NGOs), and other interested parties. The programs should be written clearly to avoid misunderstanding and confusion. Programs should include some or all of the following components:

- Identify allowable waste management options, technical standards and criteria, and associated requirements for different types of wastes;
- Specify criteria for siting, constructing, operating, and closing waste management facilities;
- Establish storage and transportation requirements, if appropriate;
- Define application, permitting, monitoring, and reporting requirements; and
- Establish compliance, inspection, and enforcement procedures, including guidance on calculating penalties and the opportunity for administrative or judicial review of enforcement actions.

### **7. Waste Management Program Requirements Should Protect the Environment and Human Health, Yet Allow for Balance and Flexibility and Consideration of Potential Risks, Costs, and Benefits**

As previously discussed, the characteristics and potential risks of different waste materials generated at E&P sites vary significantly. The nature of E&P sites also varies tremendously. Waste management programs must accommodate these differences, while still meeting the ultimate goal of protecting the environment and human health. Waste management regulatory programs should include balance and flexibility in the waste management options that are allowed and impose risk-based technical standards and criteria.

According to this general philosophy of balance and flexibility, waste management programs should try to balance the potential risks of different wastes and the stringency of the requirements governing those wastes while maintaining an adequate degree of flexibility in waste management options. A useful tool that is available to help in developing waste management programs is the formal analytical risk assessment, which includes hazard identification, dose-response assessment, exposure assessment, and risk characterization. Benefits accrue from the negative impacts that are minimized or avoided.

Careful analysis of potential risks can be done in numerous contexts. For example, at many U.S. onshore E&P sites, drilling mud reserve pits are dewatered and covered over in place (on-site burial). This waste management practice poses a low potential risk in most areas where oil and gas are produced in the United States. However, there are locations with shallow groundwater where burial is not considered environmentally sound, and there are other locations, like wells drilled in or near population centers, where burial may not be desirable. In these circumstances, a flexible and protective waste management program would allow options other than on-site burial to minimize the potential risks to the environment or health.

Another factor that should be considered for providing flexibility in waste management programs is that the costs and benefits of different waste management options be reflected. When waste management options are limited as a result of climate, geology, or lack of infrastructure, companies are left with fewer choices. Often the costs for the options that remain will greatly differ, even if the benefits are comparable. In a well-designed waste management program, options should not arbitrarily be prohibited; instead, companies should be given an opportunity to demonstrate that they can design and operate a waste management program that meets the country's goals and addresses site-specific conditions or situations in a safe, cost-effective manner.





**Environmental Science Division**

Argonne National Laboratory  
9700 South Cass Avenue, Bldg. 900  
Argonne, IL 60439-4832

[www.anl.gov](http://www.anl.gov)



UChicago ►  
Argonne<sub>LLC</sub>

A U.S. Department of Energy laboratory  
managed by UChicago Argonne, LLC